

toward being a part of a package with the Telecommunications group's CLEC services to small and medium-sized businesses. Currently, customers are obtained through agent programs and direct marketing from the Gateway unit. Soon, the direct sales force of the telecommunications division will offer long distance in conjunction with its local offerings. Recently two of the agents were fined for slamming, the illegal switching of an individual's long distance carrier onto WinStar's network, and are no longer currently part of the retail distribution network. We have accounted for the elimination of certain agent programs and lowered our 1996 revenue estimate slightly.

WinStar New Media Company

New Media produces and distributes information and entertainment content over its 38 GHz network in a broadcast and, eventually, interactive format. Revenues will be driven by sales of content, such as documentaries and foreign films, to content customers such as cable networks, on-line services and, eventually, the bundling of content through telecommunications services.

WinStar Global Products

Global Products, which was acquired prior to WinStar's entrance into the telecommunications market, manufactures, markets and distributes personal care products, primarily bath and hair care. We believe that the unit is up for sale, although WinStar will keep it for a while to provide "revenue targets" for the company. We are assuming the Global Products subsidiary will accrue over \$22 million in revenues for 1996.

Geographic Coverage

WinStar has four 100 MHz licenses in 30 markets: Atlanta, Baltimore, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Houston, Kansas City, Los Angeles, Miami, Milwaukee, Minneapolis/St. Paul, New York (LI), New York City, New York West (Newark, Northern New Jersey), Oakland, Philadelphia, Phoenix, Pittsburgh, San Diego, San Francisco, Seattle, Spokane, St. Louis, Tacoma, Tampa Bay and Washington D.C. It has one 100 MHz channel in 13 markets: Austin-San Marcos, Boise, Charlotte, Indianapolis, Jacksonville, Memphis, New Orleans, Richmond, Oklahoma City, Omaha, Portland (OR), San Antonio and Stamford.

Recent Acquisitions

In June 1996, WinStar entered into a six-year agreement with Digex, an Internet access provider that primarily serves business, government and institutional end users as well as Internet resellers. The company has agreed to purchase at least \$5 million in Internet access services with rights to purchase more on a discounted basis. WinStar will resell the service under the WinStar name through its Telecommunications subsidiary offerings.

In April 1996, WinStar agreed to acquire LOCATE for \$17.5 million, a CAP providing microwave-based local access services to corporations and long distance providers. Among LOCATE's key assets were two 38 GHz licenses, each providing 100 MHz of bandwidth in New York City including Long Island and Northern New Jersey. In addition to customers, LOCATE has roof rights to numerous buildings including the World Trade Center, which WinStar will use in its New York City CAP and CLEC operations.

**KEY OPPORTUNITIES/
RISKS****Market Acceptance**

Our primary concern is market acceptance of wireless service. There is a golden opportunity here, with the inherent risk of whether the market will utilize the service.

Market Share

There is currently one CAP/CLEC in each metropolitan area covered by WinStar's wireless licenses. The list includes ICG Communications, MCImetro, MFS Communications, Teleport and Time Warner. Although WinStar will target these companies as potential users of WinStar, many of them already are building significant infrastructures that allow them to provide local telecom services with potentially lower marginal costs than WinStar.

We have assumed year-ten market share of around 30%-40% for the competitive local telecom carriers and an average 2.2% market share for WinStar. While these may seem like aggressive targets for carving up a monopoly, they are in-line with what the upstart long distance companies, such as MCI, Sprint and WorldCom, have taken from AT&T in the business market since 1984. With more education in the marketplace now than there was ten years ago, we do not believe it will be as difficult for the local competitors to break into the business local exchange market. The chart below shows the key markets WinStar is expected to compete in, its expected market share, and the expected market share of all CLEC competitors.

**Figure 5: WinStar
WinStar Cities, Competitive Players & Year 10 Penetration**

<u>WinStar City</u>	<u>Other CLEC Competitors in WinStar Market (planned)</u>	<u>2005E WCI Market Shr.</u>	<u>2005E Total Market Shr.</u>
New York	MFST, TCGI, MCIC, T (resale), TWX, Cablevision Lightpath, ART	1%	44%
Los Angeles	MFST, TCGI, MCIC, ICG, TWX, T (resale), GST, Continental	1%	42%
Chicago	MFST, TCGI, MCIC, WCOM (resale), ART, T (resale), U.S. Network	2%	36%
Washington D.C./Baltimore	MFST, TCGI, MCIC, ART, ASCI	2%	36%
San Francisco/San Jose	MFST, TCGI, MCIC, ICG, BFPT	2%	41%
Philadelphia	MFST, MCIC, ART, Eastern Telelogic, US ONE	2%	28%
Boston	MFST, TCGI, MCIC, TWX, ART, U.S. Network	3%	42%
Detroit	MFST, TCGI, MCIC, U.S. Signal	2%	34%
Dallas	MFST, TCGI, MCIC, Metro Access Networks (CTL), TWX	3%	34%
Houston	MFST, TCGI, TWX, ART	3%	33%
Miami	MFST, TCGI, ICIX, ART	2%	33%
Atlanta	MFST, MCIC, ART, US ONE	2%	26%
Seattle/Tacoma	MFST, TCGI, MCIC, ART, GST, PacNet, Electric Lightwave	2%	30%
Cleveland	MFST, TCGI, MCIC, ICG, TWX, ART, U.S. Network	3%	30%
Minneapolis/St. Paul	MFST, ART, US ONE	3%	26%

MFST=MFS Comm., MCIC=MCImetro, T=AT&T, TWX=Time Warner, TCGI=Teleport, ICG=IntelCom, ICIX=Intermedia, BFPT=Brooks Fiber, CTL=Century Tel.

Source: Lehman Estimates

Discounted Cash Flow

Aside from the firm value/gross property, plant and equipment ratio, we have valued WinStar using a discounted cash flow analysis. With 131% of its valuation in the terminal value (near-term free cash flow is negative), we can expect volatility in the stock with interest rate increases and/or market choppiness.

Other Wireless Providers

The recent IPO of Teleport, with its BizTel's subsidiary that holds 156 licenses in the 38 GHz band, and American Radio Technology (ART) (whose IPO was recently pulled) sends a signal of competition in the 38 GHz band. New 38 GHz wireless competition will be advantageous to WinStar as customers will get more comfortable using 'Wireless Fiber'.

MANAGEMENT

WinStar is led by William J. Rouhana, chairman and CEO, who has been a director since inception. Mr. Rouhana has served as chairman since 1991 and CEO since 1994. Many influential members in the telecommunication industry have joined WinStar over the last few years. Nathan Kantor, president and COO of WinStar since September 1995, had been president of ITC Group, which specializes in the development of emerging competitive telecommunications companies. From January 1985 until December 1990, Mr. Kantor was president of MCI Telecommunications Corporation and was a founder of MCI International.

Steven Chrast, vice chairman of WinStar since January 1994, was previously a top-ranked telecommunications analyst. Frederic von Stange is currently CFO and was EVP of WinStar Companies from 1983 until November 1995. Amy Newmark is currently EVP Strategic Planning. In April 1996, the company hired David Schmieg, former president of the consumer division of Sprint Corporation to supervise the rollout of WinStar's CLEC business.

Figure 6: WinStar
WinStar Communications Annual Consolidated Earnings Model

	feb '93	feb '94	feb '95	10 Mos	dec '96	dec '97	dec '98	dec '99	dec '00	dec '01	dec '02	dec '03	dec '04	dec '05
	1993a'	1994a'	1995a'	1995a	1996e	1997e	1998e	1999e	2000e	2001e	2002e	2003e	2004e	2005e
WinStar Wireless (CAP)				675	1,671	10,100	44,150	93,892	145,112	194,451	228,444	259,196	286,152	312,621
WinStar Telecommunications (CLEC)				-	1,367	18,757	103,017	229,875	392,341	525,737	650,185	777,587	906,148	1,046,600
WinStar Gateway Network (L-D)				12,462	34,394	41,273	49,527	59,433	71,319	85,583	102,700	123,240	147,888	177,466
Total Telecommunications Revenue				13,137	37,432	70,129	196,694	383,200	608,773	805,771	981,329	1,160,022	1,340,187	1,536,687
WinStar New Media Company				2,648	15,227	25,125	32,662	40,501	48,601	57,350	66,526	75,839	84,940	94,283
WinStar Global Products (Consumer)				13,987	22,379	24,169	25,861	27,671	29,331	31,091	32,957	34,934	37,030	39,252
Revenues	11,289	15,625	25,565	29,771	75,037	119,423	255,217	451,372	686,706	894,212	1,080,811	1,270,795	1,462,157	1,670,222
Cost of Sales	9,438	10,712	17,703	19,546	48,774	72,848	142,922	225,686	336,486	420,280	497,173	571,858	643,349	726,547
Selling, General & Admin	4,807	6,888	12,689	19,267	53,276	82,402	137,817	167,008	226,613	268,264	313,435	355,823	394,782	442,609
Total Cash Operating Expenses	14,245	17,600	30,391	38,813	102,051	155,250	280,739	392,694	563,099	688,543	810,608	927,681	1,038,132	1,169,155
EBITDA	(2,956)	(1,975)	(4,827)	(9,042)	(27,013)	(35,827)	(25,522)	58,678	123,607	205,669	270,203	343,115	424,026	501,067
Depreciation	69	93	177	770	5,319	56,319	60,319	66,319	75,319	84,319	93,819	104,269	115,242	126,444
Operating Income (Loss)	(3,025)	(2,068)	(5,004)	(9,812)	(32,333)	(92,146)	(85,841)	(7,641)	48,288	121,349	176,384	238,846	308,784	374,623
Other Income (Expenses)														
Interest Expense	534	635	252	4,740	32,603	64,172	73,183	89,463	101,188	108,340	109,738	109,738	109,738	109,738
Amortization of Intangibles/(Int Inc.)	566	240	225	439	-	-	-	-	-	-	-	-	-	-
Equity in Loss of AGT & Other	(75)	(162)	1,141	866	-	-	-	-	-	-	-	-	-	-
Income Tax Expense (Benefit)	-	-	-	-	-	-	-	-	-	-	7,997	28,404	53,742	79,465
Net Income (Loss)	(4,050)	(2,781)	(6,623)	(15,857)	(64,935)	(156,318)	(159,024)	(97,104)	(52,900)	13,010	58,648	100,704	145,303	185,419
Earnings (Loss) Per Share	(0.80)	(0.36)	(0.37)	(0.70)	(2.33)	(3.91)	(3.67)	(2.24)	(1.21)	0.30	1.34	2.29	3.29	4.18
Wtd. Average Shares Outstanding	5,066	7,719	17,122	22,770	27,916	40,007	43,282	43,432	43,582	43,732	43,882	44,032	44,182	44,332
Fully Diluted EPS				(1.58)	(2.94)	(2.82)	(1.72)	(0.93)	0.23	1.03	1.76	2.53	3.22	
Fully Diluted Shares Outstanding				41,100	53,191	56,466	56,616	56,766	56,916	57,066	57,216	57,366	57,516	

Source: Company Reports and Lehman Estimates

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Figure 7: WinStar

WinStar Communications Annual Revenue Growth and Expense Margin Model

	1993a'	1994a'	1995a'	1995a	1996a	1997e	1998e	1999e	2000e	2001e	2002e	2003e	2004e	2005e
Revenue Growth														
Revenue		38.4%	63.6%	16.5%	152.0%	59.2%	113.7%	76.9%	52.1%	30.2%	20.9%	17.6%	15.1%	14.2%
Expense Growth														
Cost of Sales		13.5%	65.3%	10.4%	149.5%	49.4%	96.2%	57.9%	49.1%	24.9%	18.3%	15.0%	12.5%	12.9%
Selling, General & Admin		43.3%	84.2%	51.8%	176.5%	54.7%	67.3%	21.2%	35.7%	18.4%	16.8%	13.5%	10.9%	12.1%
EBITDA Growth		n/m	n/m	n/m	n/m	n/m	n/m	n/m	110.7%	66.4%	31.4%	27.0%	23.6%	18.2%
Depreciation		34.2%	91.4%	334.7%	590.6%	958.8%	7.1%	9.9%	13.6%	11.9%	11.3%	11.1%	10.5%	9.7%
Expenses As % of Revenues														
Cost of Sales		68.6%	69.2%	65.7%	65.0%	61.0%	56.0%	50.0%	49.0%	47.0%	46.0%	45.0%	44.0%	43.5%
Selling, General & Admin		44.1%	49.6%	64.7%	71.0%	69.0%	54.0%	37.0%	33.0%	30.0%	29.0%	28.0%	27.0%	26.5%
Depreciation		0.6%	0.7%	2.6%	7.1%	47.2%	23.6%	14.7%	11.0%	9.4%	8.7%	8.2%	7.9%	7.6%
EBITDA Margin		-12.6%	-18.9%	-30.4%	-36.0%	-30.0%	-10.0%	13.0%	18.0%	23.0%	25.0%	27.0%	29.0%	30.0%
Operating Margin		-13.2%	-19.6%	-33.0%	-43.1%	-77.2%	-33.6%	-1.7%	7.0%	13.6%	16.3%	18.8%	21.1%	22.4%
Net Margin		-17.8%	-25.9%	-53.3%	-86.5%	-130.9%	-62.3%	-21.5%	-7.7%	1.5%	5.4%	7.9%	9.9%	11.1%

Source: Company Reports and Lehman Estimates

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Figure 8: WinStar
WinStar Communications Annual Free Cash Flow Model

	ten months											
	1994a	1995a	1996e	1997e	1998e	1999e	2000e	2001e	2002e	2003e	2004e	2005e
EBITDA	(1,975)	(4,827)	(9,042)	(27,013)	(35,827)	(25,522)	58,678	123,607	205,669	270,203	343,115	424,026
+ Change In Working Capital	0	0	0	0	0	0	0	0	0	0	0	0
- Capital Expenditures			50,000	280,000	160,000	110,000	100,000	95,000	95,000	99,750	104,738	109,974
- EBIT * (tax rate)	0	0	0	0	0	0	0	0	26,458	83,596	108,074	131,118
Free Cash Flow	(1,975)	(4,827)	(59,042)	(307,013)	(195,827)	(135,522)	(41,322)	28,607	84,211	86,857	130,303	182,933

Figure 9: WinStar
WinStar Communications Valuation

	1996e	1997e	1998e	1999e	2000e	2001e	2002e	2003e	2004e	2005e
Total EBITDA	(27,013)	(35,827)	(25,522)	58,678	123,607	205,669	270,203	343,115	424,026	501,067
Total Free Cash Flow	(59,042)	(307,013)	(195,827)	(135,522)	(41,322)	28,607	84,211	86,857	130,303	182,933

Discounted Cash Flow Assumptions		Baseline			
EBITDA (2005e \$000)		501,067			
multiple (x)		9 x	10 x	11 x	12 x
Fair Market Value		4,509,599	5,010,666	5,511,733	6,012,799
Discount rate (%)		14.0%			
NPV of 1996-2005 free cash-flow stream		(405,107)	(405,107)	(405,107)	(405,107)
NPV of EBITDA terminal value in 2005		<u>1,386,738</u>	<u>1,540,820</u>	<u>1,694,902</u>	<u>1,848,984</u>
Net Present Value		981,631	1,135,713	1,289,795	1,443,877
Total Net Debt Outstanding, Yr End 1996		120,145			
Year-End Net Asset Value		861,486	1,015,568	1,169,649	1,323,731
Public Market Discount:	30%	603,040	710,897	818,755	926,612
	25%	646,114	761,676	877,237	992,799
	20%	689,188	812,454	935,720	1,058,985
Shares Outstanding		28,150			
1996 Year-end Price Per Share		21.42	25.25	29.09	32.92
		22.95	<u>27.06</u>	<u>31.16</u>	35.27
		24.48	28.86	33.24	37.62

Source: Company Reports and Lehman Estimates

GLOBAL EQUITY RESEARCH

New York (1) 212 526-3070 London (44) 171 601-0011-5524 Tokyo (81) 3 5571-7462 Hong Kong (852) 2869-3541

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Future Shock

How PCS will Broadside the Local Loop—Why Telcos Ought to Worry

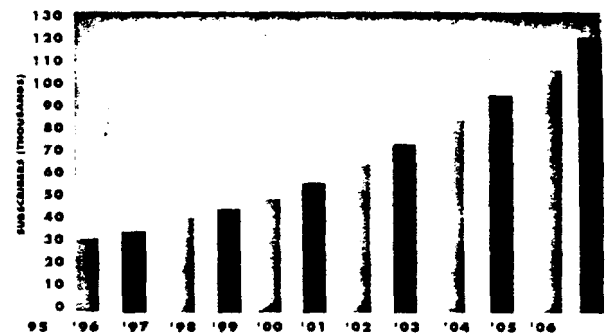
By Gary Kim

As the gale of competition slams into U.S. local exchange carriers, loop resale will provide the first gusts. But survival may hinge on how well LECs meet the challenge of facilities-based attackers, especially those based on wireless technology. Without slighting the importance of loop unbundling and pricing mechanisms, the economics are relatively simple.

When a local telephone company unbundles its facilities and sells them wholesale, revenue is reduced, but probably only to about 85% of the retail level for the leased network elements. But resale also offers the incumbent carrier reductions in marketing, customer care and overhead. When access lines are lost to facilities-based competitors, the in-place carrier loses the entire account.

According to executives at Morgan Stanley, LECs must brace for loss of 35% of their high-margin business cus-

U.S. Cellular/PCS Market Subscribers



tomers and 25% or more of their residential share over a 10-year period. But the investment banking concern estimates that only about 9% of the lost share will be to facilities-based carriers. If facilities-based carriers snag more—20 to 25%—catastrophe awaits.

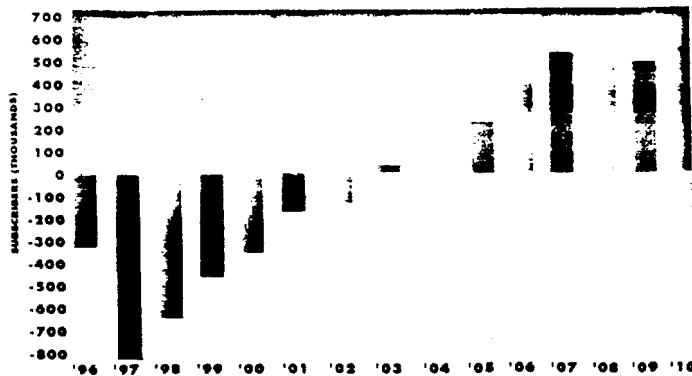
Nevertheless, carriers must vigorously work at achieving operating efficiencies, limiting overall share losses and growing new revenue streams. As the following case studies will indicate, success in virtually all three areas is essential if local telcos are to survive.

Wireless local loop, using personal communications service spectrum, could be troublesome precisely because it strands investment, raises overhead on each of the remaining lines and drains revenue at a dramatically higher rate than resale operations.

The threat is real. Researchers at Austin, Texas-based Technology Futures Inc., for example, anticipate that cellular/personal communications service (PCS) customers will represent 86 million U.S. "access lines," compared to 184 million wireline connections, by the turn of the century. Andersen Consulting, meanwhile, predicts that mobile subscribers could represent 17% of wireline customers by that point.

**By 2010,
Technology Futures
sees a whopping 223
million wireless
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connections.**

Cash Flow One PCS Co. Providing WWL



WHOPPING WIRELESS

By 2010, Technology Futures sees a whopping 223 million wireless customers, and 247 million wireline connections. If true, the wireless access market would be 81% the size of the U.S. wireline market. Cedar Knolls, N.J.-based Probe Research Inc. sees 60 million cellular/PCS customers by 2000. Acton, Mass.-based Edge Media calls for a whopping 60 million PCS and 52 million cellular customers in the U.S. in 2000.

PER-SUBSCRIBER COST OF LOOP TECHNOLOGIES AT 10% PENETRATION, \$/SUBSCRIBER

Component	Cellular	PCS	Cablephone
Wire center	60	60	60
Switch	190	190	190
Network interface	50	50	225
Backhaul	100	100	40
Remote terminal	2,160	400	0
Customer equipment	300	300	120

THE BUSINESS CASE

The extent to which PCS and cellular will be embraced by consumers as replacements for wireline connections remains unclear. Also unclear is the viability of some facilities-based approaches at low penetration (10% of potential homes). Some analysts, such as Boulder, Colo.-based Hatfield & Associates and Boston-based Economics & Technology, have argued that "cellular radio is an unlikely replacement for the existing LEC telephone service," based on studies of a hypothetical community of 80,000 homes, with a 2,230 homes per square mile density. Though networks based on lower-cost PCS or hybrid fiber

coax technology might fare better, the two companies still warn of a "long, hard climb for cable and wireless providers who plan to provide local telephone service in competition with the LECs."

Based on extensive modeling of a hypothetical community of 200,000 potential customers, the firms suggest that penetration of 18%, with a basic monthly fee of up to \$35,

KEY ASSUMPTIONS, WIRELESS DROP BUSINESS CASE COMMUNITY OF 50,000, "TOP-DOWN" CAPITAL INVESTMENT MODEL

Spectrum rights	\$20/POP
Capex	\$40/POP
Switching	\$1 million
Cost of capital	18%
New sub marketing cost	\$200
Handset subsidy, new subs	\$375
Mktg cost, existing subs	\$50
Overhead, percentage of revenue	30
Initial monthly bill	\$42

plus additional revenue of \$20 a month, probably is required to assure positive cash flow after five to eight years of operation.

Probe Research models of wireless drop competition are in rough accord with these estimates, suggesting a cash flow positive position in as few as four, and as many as seven years, for a relatively straightforward macrocell network. The Probe model, using both a "top-down" and "bottom-up" capital investment methodology, includes the cost of acquiring spectrum at \$20, monthly revenue of \$42 per subscriber, dropping to \$32 per subscriber over 14 years. Probe assumed 44% wireless penetration after 14 years, with three providers dividing the market equally between them.

The "top-down" capital model used modified cellular industry rules of thumb for infrastructure, while the "bottom-up" model used costs for switching, RF transmission and real estate that are a blend of TDMA and CDMA costs.

Probe looked at several different technology variations, including macrocell, modified macrocell (one half the macrocell radius) and distributed microcell architectures.

KEY ASSUMPTIONS, WIRELESS DROP BUSINESS CASE COMMUNITY OF 50,000, "BOTTOMS-UP" CAPITAL INVESTMENT MODEL*

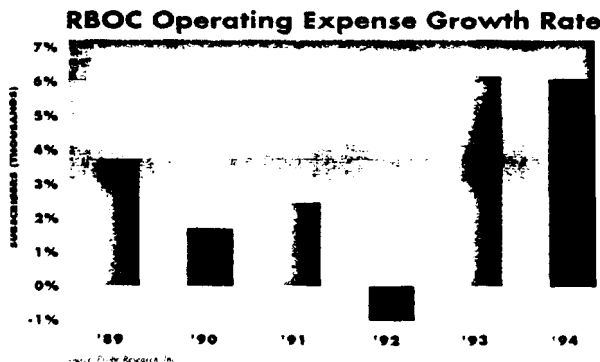
Fixed cost (land, building)	\$100,000
Radios	\$50,000
Base station controllers	\$300,000
Software licenses, maintenance/yr.	\$120,000
Controller maintenance/yr.	\$480,000

*Network penetration assumptions same as for "top down" capital model.

Source: Prime Research, Inc.

In one version of the exercise, using a distributed antenna approach with hybrid fiber coax signal trunking and strand-mounted local antennas, a cash flow positive position was reached only after seven years, owing primarily to low penetrations for all PCS contenders in the one community of 50,000 people.

Assume a total wireless penetration of 44% at the end of the period, with each of three companies sharing the market equally, at about 14% of POPs each. Assume all the PCS contenders are facilities based, have paid for their spec-



trum rights, and use their own switching and radio infrastructure. Leased access obviously would lower costs significantly.

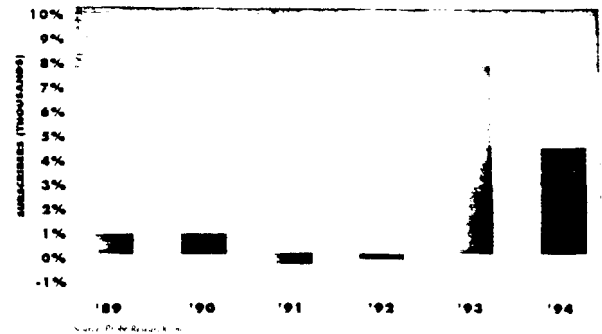
LEC IMPERATIVES

Despite widely-publicized downsizing efforts, LECs cannot let up on efficiency efforts if they hope to compete successfully with facilities-based networks. In fact, RBOC operating expense jumped dramatically beginning in 1993, and stayed higher in 1994, based on the latest available data from the Federal Communications Commission.

Those efficiencies probably cannot be driven by downsizing, however. Employee costs represent a declining portion of overall costs, falling since 1988.

The picture also is mixed in the area of maintenance costs, which represent more than 25% of total RBOC oper-

RBOC Plant Expense Other than Maintenance % Increase



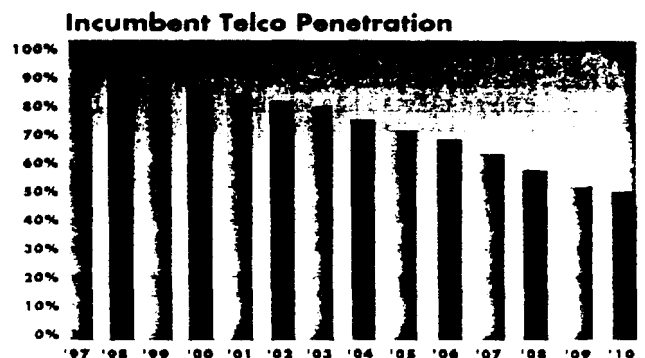
ating expense. RBOC maintenance costs have been erratic in recent years.

In the important plant operations area (excluding maintenance), representing 40% of total RBOC operating expense, a strong upward trend occurred in 1993 and 1994, compared with 1988 to 1992. This category includes the cost of power, network administration, testing, operations, engineering, access and depreciation. Accelerated depreciation is an important factor here.

Operating costs will be a key LEC weapon in the combat with facilities-based carriers for one compelling reason: they are largely insensitive to traffic and penetration. That is to say, the cost of serving one high-volume customer, located right next to a low-volume customer, is virtually identical. Likewise, the cost to operate a network serving 70% of customer sites in a neighborhood, compared to 100%, is quite similar. In other words, the "avoided" operations costs will be minimal as new facilities-based contestants start eroding LEC market share.

CASE STUDY I

To illustrate the impact of competition on local telcos, consider one community of 44,400 initial access lines and 27,400 homes, where the incumbent telco faces "loop resale," facilities-based wireless and wireline carriers. Based on current median access line revenue for the BOCs, assume initial monthly revenue of about \$54 for our test case telco, including \$26 for local service, \$16 for access, \$6 for toll and \$6 in other revenue.



RBOC REVENUE/ACCESS LINE

	Total	Local rev.	Access	Toll	Other
Ameritech	48	25	13	6	4
Bell Atlantic	51	24	14	7	7
BellSouth	59	29	17	5	12
Nynex	58	34	17	5	2
Pacific Telesis	49	20	13	9	8
SBC	51	25	17	5	3
US West	52	24	18	7	4
Verizon	53	26	16	6	6

Sources: Morgan Stanley and Probe Research estimates

Other assumptions:

- 1.2 access lines per home, growing to 2.0 in 2010
- 1% wireless penetration, growing to 36% in 2010
- 3% resale penetration, growing to 18% in 2010
- Facilities-based wireline competition in 1998, at 1%, growing to 13
- Flat pricing for basic monthly service (competition tends to reduce prices, but residence lines are priced below actual cost, and will tend to rise to meet cost)
- Access charges/minute decreasing about 65% between 1997 and 2010
- Toll revenue decreasing by half between 1997 and 2010
- Enhanced services revenue increasing by 3.5 times between 1997 and 2010

RBOC OPERATING EXPENSE, MARKETING, CAPITAL SPENDING/ACCESS LINE

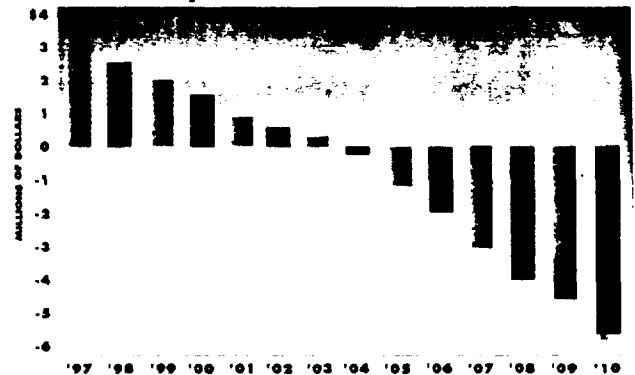
Carrier	1995	2010
Ameritech	504	480
Bell Atlantic	447	411
BellSouth	549	512
Nynex	575	532
Pacific Telesis	453	433
SBC	488	442
US West	421	468
Verizon	421	468

Sources: Probe Research, Morgan Stanley and Probe Research estimates

- Operating expense, marketing, capex/line dropping from \$507 to \$473
- Dividend payments continue, but do not increase
- Wholesale loop elements are sold at 85% of retail
- No increase in capital spending for residential broadband
- No capital spending or asset purchases of long-distance assets

In this scenario, the incumbent telephone company's share of the market drops from 96% in 1997 to 50% in 2010, with loop resale firms representing 3% of the market initially, and growing to 18% in 2010. Facilities-based market share will be zero in 1997, growing to 13% by 2010.

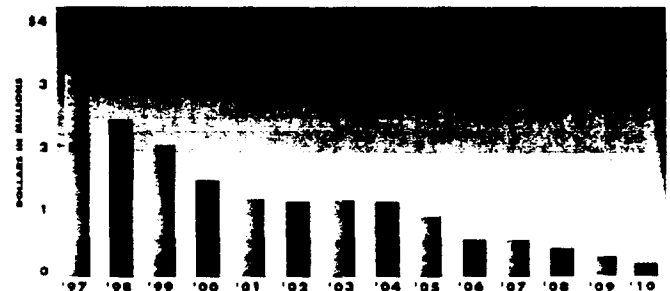
Case Study Local Telco Cash Flow



In this scenario, for example, local telco revenue in 1997 is about \$20.5 million, growing to \$27 million in 2010.

The problem is that, based on the modeled declines in cost per line, and the projected losses to competitors, expenses outstrip revenue. Make no mistake, prosperity is no longer the issue. Survival is the issue. In this case, loss of half the local market by 2010, despite continued reductions in operating expense, and share loss of 32% share to facilities-based carriers, creates a cash-flow negative situation as early as 2004.

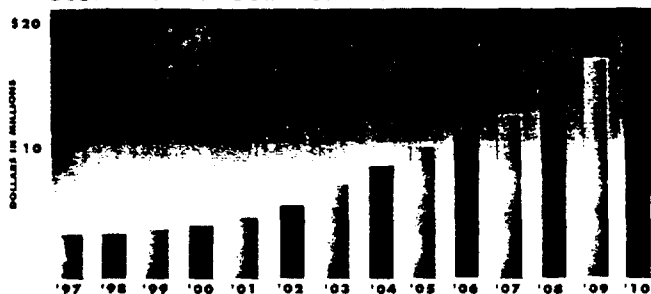
Scenario II: Local Telco Cash Flow



CASE STUDY II

To determine a sustainable business case for the case study telco, leave all inputs the same as for scenario I, but reduce competitor market share to 35% by 2010, with facilities-based wireless and leased-access carriers getting 13% share each. A wireline facilities-based carrier gets 9% share. In this case, cash flow remains positive, but drops steadily. The implication is that share loss of 35% between 1997 and 2010 is an unacceptable business proposition, since it most likely leads to liquidation of the business.

Scenario III: Local Telco Cash Flow



SCENARIO III

Our third scenario retains the penetration assumptions of scenario II, specifically share loss of only 35% by 2010, but reduces operating costs per access line an additional 5% per year over the entire period. This clearly is a sustainable proposition, even without assuming more robust revenue growth per access line.

Scenario III: Operating Costs/Access Line



Scenario III operating costs per access line in 1997 are a bit over \$500 in 1997, declining to only \$260 per access line in 2010, a breathtaking decline that exceeds anything yet seen in the local exchange, or generally predicted by carrier executives and analysts following the business.

The implications are stark. Local exchange carriers probably must strive even more dramatically to break the current operating cost paradigm, hope for share loss of only 35%, or find some way to dramatically boost revenues

without taking on new capital spending programs. The success facilities-based carriers enjoy will prove crucial, since every customer they take will raise per-access-line operating costs for the incumbent LEC. Loop resale cushions the cash flow picture dramatically, reducing revenue only about 15%—and just as important—putting the brakes on increases in per-line operating cost. Wireless carriers are the opponents to watch.

The emergence of PCS dramatically boosts local loop "POTS" bandwidth. Compared to cellular telephone, PCS represents a tripling of spectrum, while digital air access represents an efficiency increase of 10 times analog cellular. Cellular carriers moving to digital will further increase capacity. And though current thinking is that cellular networks cannot provide economical wireless drop, new microcell technologies, including the "distributed antenna" concept for hybrid fiber coax networks, and much-better antenna and power-handling technologies, such as Nortel's SmartBTS, are changing thinking.

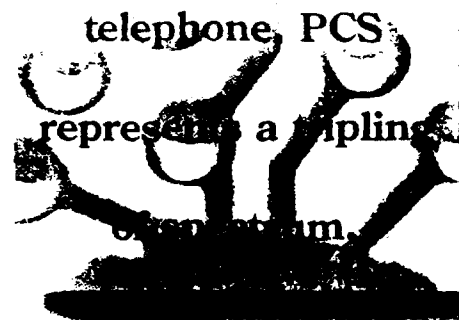
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DISTRIBUTED ANTENNA

The distributed antenna, under development by such companies as ADC Telecommunications and Sanders, a Lockheed Martin Co. affiliate, allow strand mounting of small radio transceivers on standard coaxial cable, avoiding the cost normally associated with cellular transmit sites. Nortel's SmartBTS also helps, as it overcomes the distance penalty associated with 1.9 GHz PCS frequencies, which travel only half as far as the lower-frequency cellular signals in the 800-MHz range. The direct implication is that a macrocell PCS network requires no more base stations than a standard cellular network. That, in turn, means a four-fold reduction in the number of required transmit locations.

LECs must simultaneously move to limit potential share losses, boost per-line revenue while destroying the existing cost paradigm. Since boosting per-line revenue and limiting competitor share are not entirely controllable, the task of fundamentally transforming operations stands as the key task. Failure is not an option, since it likely means extinction.

Compared to cellular



carriers must make a critical choice to make and determine which technology to deploy within a market in which only 600 million phones exist for the 6 billion people who inhabit the earth. Traditional wireline, fiber-based wireline and wireless-based loop technologies like code division multiple access and digital enhanced cordless telephones are some of the alternatives. The choice is critical because it affects service quality, capital expense, operating expense and, ultimately, business valuation and success.

THE WIRELESS LOCAL LOOP: A MATTER OF SIMPLE ECONOMICS

NATE PALMER

Until recently, wireline loop technologies dominated both existing and planned fixed access networks. Technological advancements have made wireless technology a cost-effective alternative for areas where fixed access service is either insufficient or nonexistent.

The local loop has traditionally been defined as a dedicated pair of copper wires connecting the subscriber phone to the central office switch, forming a loop. Modern wireline networks often use concentration to reduce the number of pairs to be deployed, but the basic architecture has not changed substantially since Alexander Graham Bell was making calls.

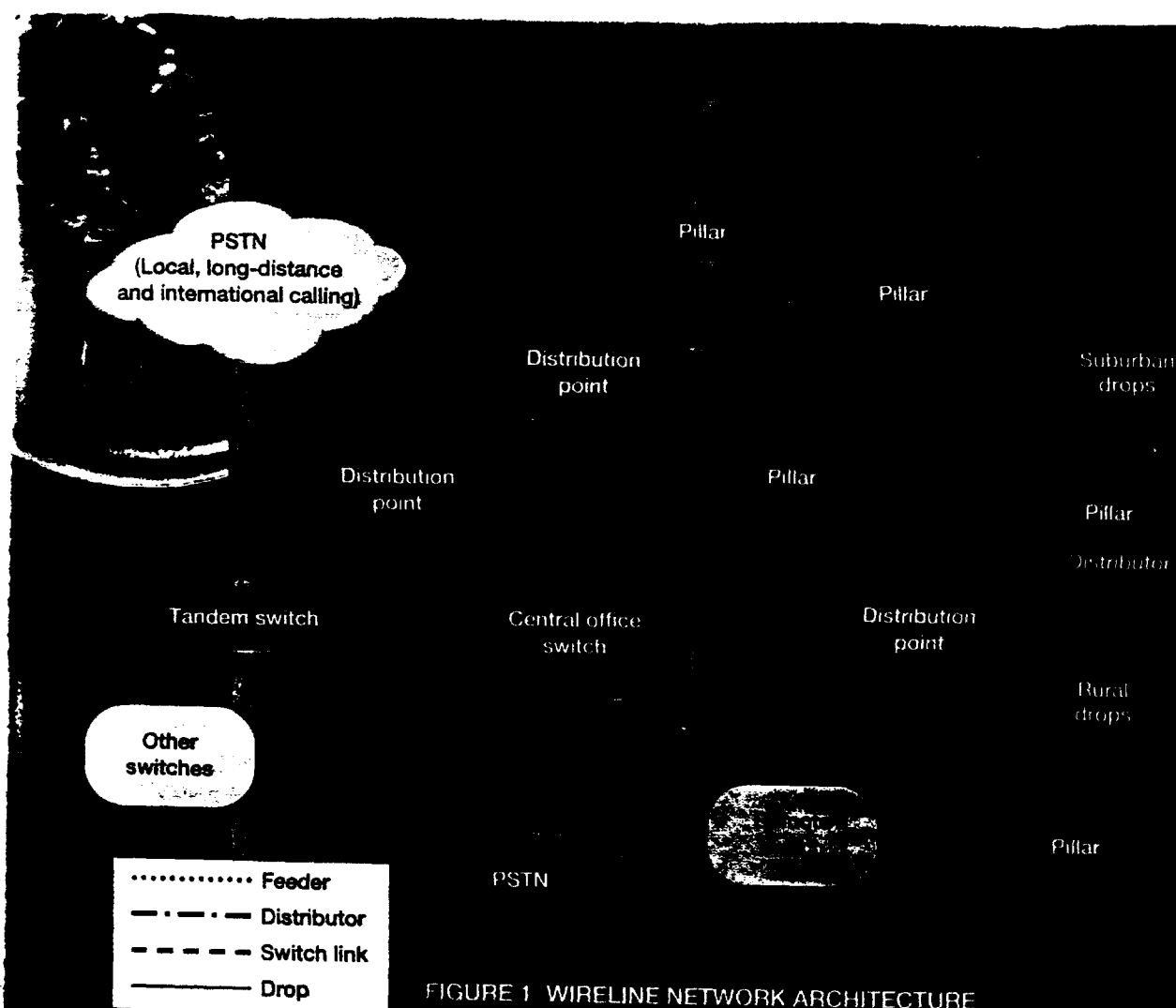


FIGURE 1 WIRELINE NETWORK ARCHITECTURE

In the wireline local loop network architecture, the CO switch acts as the network hub where high-capacity feeders connect to begin the call routing process (Figure 1). Calls are carried from the switch through the feeder to a distribution point where they are redirected through a distributor. Distributors carry call traffic to another line, called a pillar, where each call is separated and routed individually through the drop. The drop then carries the call to the subscriber's business or residence.

Wireless local loop technologies allow telephone service providers to use radio spectrum and radio-based equipment instead of wires. Wireless local loop is different from other wireless technologies, such as cellular, satellite and microwave because it is specifically designed and optimized for local loop use. By concentrating resources on fixed rather than mobile services, wireless local loop can provide greater capacity at a lower cost than mobile service (Figure 2).

A number of technologies are available for service providers looking for a wireless local loop option. For DECT and CDMA technologies are the most common choices.

DECT is a picocellular wireless system that provides a radio interface between the subscriber and the fixed network to support wireless local services in high-

Wireless Local Loop *continued*

density fixed access applications. The DECT system employs a concentration of small-radius base stations, each linked to a base station controller, which is linked to the switching network.

Typical applications include office buildings and other very dense subscriber environments where demand per kilometer is high and cell coverage area is not a critical requirement. The small cell radii and relatively low-cost base stations and controllers also make DECT appropriate for filling small coverage holes in an existing fixed network.

The DECT radio interface is based on time division

CDMA is a digital wideband, spread spectrum technology that transmits multiple independent conversations across single or multiple 1.25 MHz bands of radio spectrum. Each voice, data or fax transmission is assigned a unique digital code that distinguishes it from other calls that share the same spectrum. The CDMA system features large cell radii and the highest capacity of any wireless technology. This combination makes CDMA wireless local loop ideal for large roll-outs covering urban, suburban and rural morphologies.

In the CDMA system, each base station contains

one or more RF carriers that provide up to 45 voice channels per sector within 1.25 MHz of spectrum (1.25 MHz for sending + 1.25 MHz for receiving = 2.5 MHz total for each carrier). Each RF carrier can be split into sectors that concentrate capacity in a particular direction.

For a three-sector cell site, one RF carrier can provide up to 135 voice channels. In a market where a 20 MHz spectrum allocation enables seven frequency bands to operate, a three-sector cell provides as many as 945 voice channels in one cell site. Increasing sectorization to six or nine sectors will further increase cell site capacity. This extremely high capacity per cell is one of the biggest advantages of CDMA technology.

Simple Economics

These technological and architectural differences result in a number of key advantages for wireless local loop systems, including faster deployment, better coverage flexibility, lower operating ex-

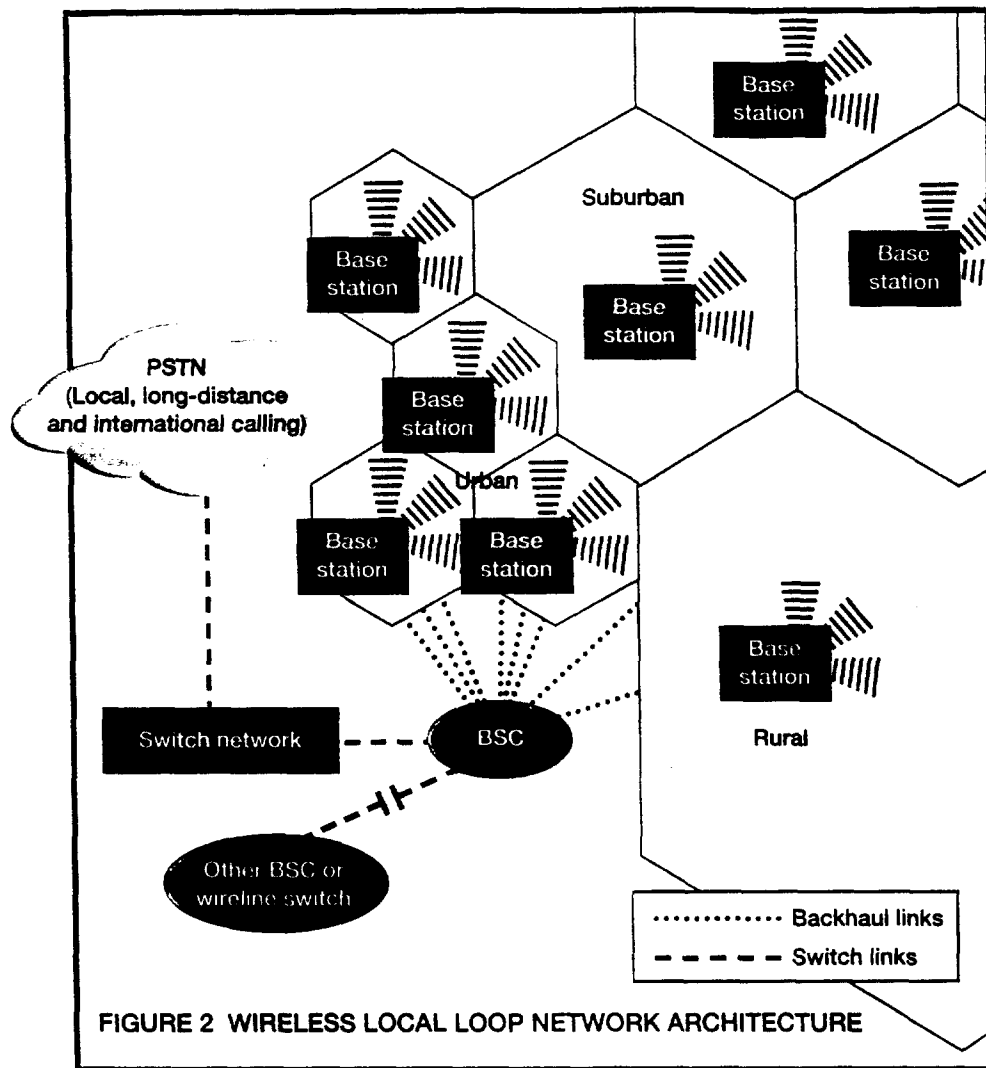


FIGURE 2 WIRELESS LOCAL LOOP NETWORK ARCHITECTURE

multiple access technology. It operates over 10 radio carriers in the 1880 to 1900 MHz band. DECT uses dynamic channel selection, an automated frequency-planning mechanism, to select the channel with the least interference from neighboring cells or sectors.

Because of frequency reuse limitations, the maximum number of voice channels available for a single cell site in a multicell environment is 60. To provide high capacity per unit area, the DECT system transmits at low power using low antenna heights, enabling small cell sites to use all 60 channels and reduce interference from all but the neighboring cell sites.

pense and lower capital expense. Deployment speed is important to service providers because time to market and time to revenue are critical in gaining market share and reducing financing requirements.

Wireline networks take more time to deploy than wireless local loop networks because they require government right-of-way authorization to dig trenches through public streets. The process of routing cable to individual households is also much more time-consuming than deploying wireless base stations, which are shared by many subscribers.

Wireless local loop networks also enable service

continued on page 64

Wireless Local Loop *continued*

providers to adjust coverage and capacity to match subscribers' location and demand at any time. Wireline networks, which need to be built far in advance of anticipated demand, are much less flexible.

Operating expenses are lower for wireless local loop networks because centralized facilities provide fewer points of potential failure and make it easier to resolve troubleshooting problems. In contrast, wireline networks have widely dispersed equipment that is more susceptible to accidental damage, vandalism and severe weather—increasing maintenance requirements and network operating expenses.

To effectively evaluate and compare different network technologies, a telecommunications operator must understand how the strengths and weaknesses of each technology contribute to the overall cost and performance of a network. The economic model used in this analysis was developed by Pittiglio, Rabin, Todd and McGrath to analyze fixed access networks from a service provider's perspective.

Figure 3 shows the capital cost per subscriber for each technology option during a 10-year network roll-out. The analysis is based on a newly deployed "greenfield" network requiring full local loop coverage as well as switching and switch interconnect equipment.

The model region, Gujarat, India, is typical of many areas in the world that are in the process of issuing fixed access licenses to service providers. The results indicate that the capital requirements for DECT and wireline networks are substantially higher than those for CDMA networks. The extensive coverage area in this scenario, which includes suburban and rural morphologies, creates a costly network for the DECT operator that has to deploy many small-radius cells in the area.

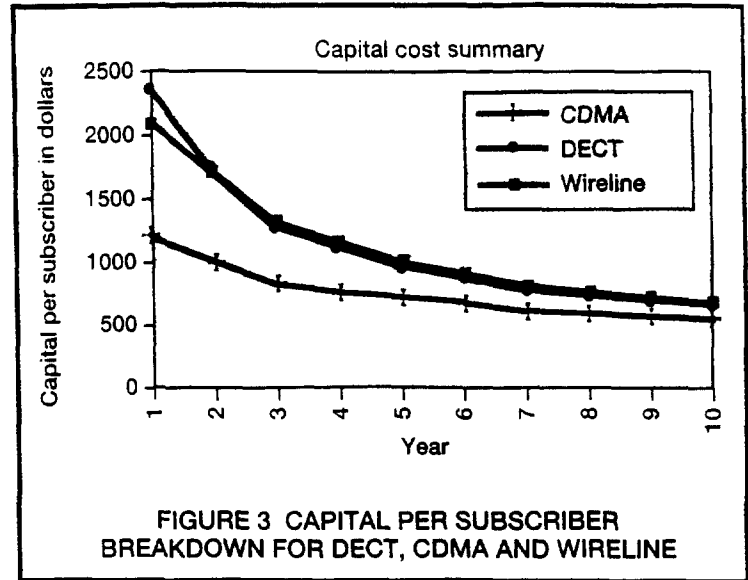


FIGURE 3 CAPITAL PER SUBSCRIBER BREAKDOWN FOR DECT, CDMA AND WIRELINE

Even in India, which has one of the lowest wireline cost structures in the world, the wireline network is more expensive than a wireless local loop network. The high costs associated with burying and modifying traditional wireline networks make it necessary for service providers to anticipate capacity requirements four to six years into the future. This advanced build-out creates high costs per subscriber, especially in the early years of deployment, and increases peak financing requirements.

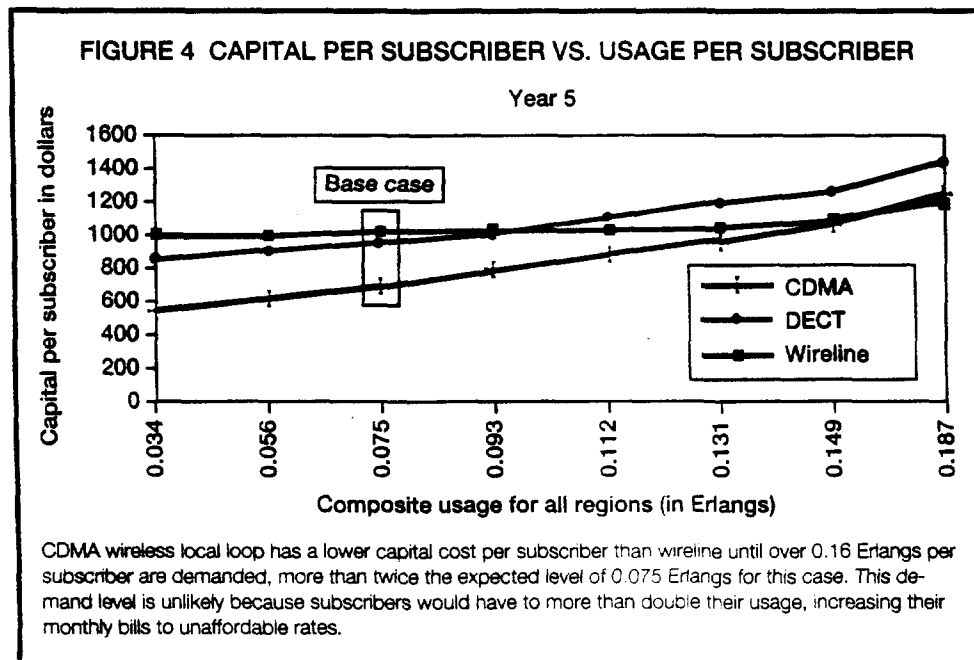
Subscriber usage and density can be measured using a sensitivity analysis. Perhaps the most useful application of an economic model, the sensitivity analysis allows users to understand how changing key variables affects business outcomes. It also helps to optimize the final network solution by allowing ideas to be tested before investing in and deploying a network.

Because wireline subscribers have a dedicated line

to their residence or business, the level of use has no effect on the capital cost per subscriber for the loop portion of the network. Wireless technologies are more modular because subscribers share base station channel resources. Channel capacity at a base station is easily expanded, allowing the wireless service provider to match system capacity with subscriber demand. This is especially significant in low-usage scenarios because the wireless service provider can minimize the capital outlay. Figure 4 demonstrates these subscriber usage dynamics.

Telephone market pen-

continued on page 66



CDMA wireless local loop has a lower capital cost per subscriber than wireline until over 0.16 Erlangs per subscriber are demanded, more than twice the expected level of 0.075 Erlangs for this case. This demand level is unlikely because subscribers would have to more than double their usage, increasing their monthly bills to unaffordable rates.

Wireless Local Loop *continued*

etration and market share are difficult to predict and require the evaluation of a range of potential subscriber densities and average loop lengths. Wireline networks are very sensitive to subscriber density and loop length because longer loops require longer fiber and copper lines, longer trenches and more telephone poles. As a result, wireline technologies are cost-competitive in urban areas where densities are high and loop lengths are short.

In contrast, CDMA technology is insensitive to loop

length because no physical link is required, and the large cell radii allow the base station to operate efficiently even in situations with low subscriber density. The DECT network is more sensitive to low-density scenarios than the CDMA network because the small cell radii prevent each base station from covering enough subscribers to efficiently use the capacity.

Capital per subscriber as a function of subscriber density and loop length are shown in **Figure 5** for the urban morphology only. In this analysis, the CDMA

network has the lowest capital cost per subscriber for all densities below 880 subscribers per square kilometer and above an average loop length of 1.58 km. Above this subscriber density and for shorter loop lengths, wireline has the lowest capital cost per subscriber.

In suburban and rural morphologies, the larger cell radii for the CDMA network makes it the most cost-effective technology. Longer loop lengths and lower densities in these regions make wireline and DECT technologies inefficient, driving up the capital cost per subscriber.

Wireless local loop technologies provide significant advantages over their wireline competitors—including faster deployment, better coverage flexibility, lower operating expenses and lower capital expenses—which ultimately lead to improved business valuation and success.

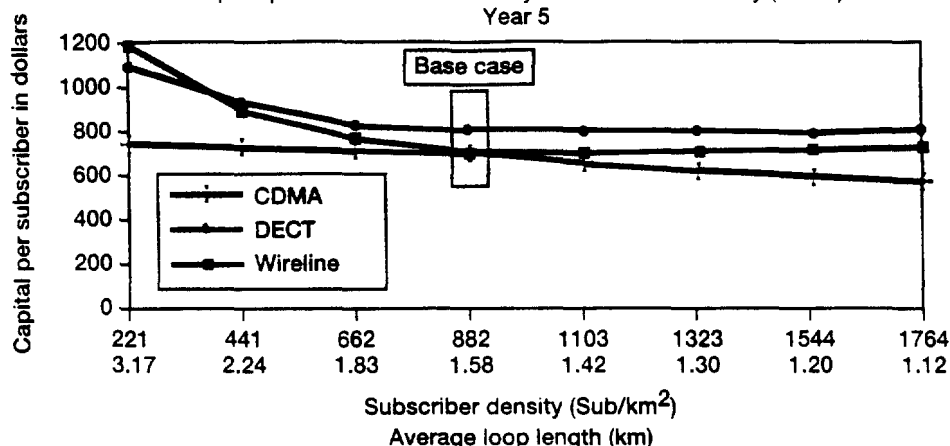
The CDMA wireless local loop technology is optimal for wide area coverage. In scenarios with smaller coverage areas, fewer subscribers and a denser environment than the scenarios modeled in this analysis, DECT may be more cost-effective.

Telecommunications and other information technologies are essential to helping people of all regions improve productivity and create wealth. A local loop service provider searches for a system that is easy to deploy, flexible and cost-efficient to procure and maintain. It is evident that wireless local loop technologies are quickly becoming a viable alternative to satisfy these needs. ■

Nate Palmer is an Associate at Pittman, Todd and McGrath, Mountain View, Calif.

FIGURE 5 URBAN CAPITAL PER SUBSCRIBER VS. SUBSCRIBER DENSITY

Capital per subscriber sensitivity to subscriber density (urban)
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NS FOR NEW TECHNOLOGIES

DAVID KOPF AND PETER MEADE

Wireless Lo

Made for the USA?

As the domestic market slowly starts to evolve, carriers need to survey the various applications and define the technologies in order to understand which ones will best serve them.

Forecasting the size and scope of the U.S. Wireless Local Loop (WLL) market is a bit like tornado spotting—you have little idea of where or when it's going to happen, but you know it will.

How the wireless local loop will take shape in the United States depends on constantly evolving market needs and the widely varying technologies from which carriers will have to choose. Compounding the degree of difficulty in the decision, however, is the debate over what actually constitutes a wireless local loop?

One thing is for certain: Many times when the discussion centers around the wireless local loop, the conversation immediately exits the U.S. for remote corners of the globe. Telephony-starved countries such as India, Turkey and Russia have proven to be fertile proving grounds for wireless local loop technology.

Having made a name for itself out of town, WLL is now trying to make its mark on the homeland. But does this mean the made-in-the-USA technology is ready for the domestic market?

DEFINING THE WLL

Perhaps part of the reason this is still at question is that when querying U.S. industry watchers about the prospects of domestic wireless local loop, they immediately respond with a bevy of other acronyms, including CDMA, CDPD, DBS, GSM, LMDS, MMDS and PCS. Definitions and

directions seem to vary by manufacturer and telco.

"You have to identify the baselines first," says Mark Vida, vice president and general manager of Clearwater, Fla.-based Tadiran Telecommunications Inc.'s Network Systems. "One thing that's very confusing to the market right now is that there is no single definition of PCS, and certainly no definition for wireless local loop. Some people use fixed wireless local loop and PCS in the same breath."

Echoes Randy Carlson, an industry analyst at the Boston-based Yankee Group: "The wireless local loop offers a whole range of technology options. But whatever the option, it must prove to be more attractive than the entrenched wireline network."

From Tadiran's point of view, Vida says a viable wireless local loop must offer the same capabilities as the copper local loop. In other words, it must:

- provide toll-quality voice;
- transmit data up to ISDN rates;
- be able to extend service from the central office to about five miles, like a copper network;
- have a low license cost similar to copper networks;
- offer customers a pricing scheme equivalent to or better than copper.

"If you use that same definition for wireless local loop, it's the same as copper," Vida says. "But, if you sacrifice one of those elements—say, you don't want toll-quality voice... there is an overlap."

Aside from what the wireless local loop can provide, the wireless part of that definition should portray a network of fixed, but mobile, users, says Bill Marsh, director of product management for Motorola's Arlington Heights, Ill.-based wireless access systems unit. "It is the delivery of uninterrupted telecommunications services to a person that is fixed in a given point of time and location."

FIXED MOBILE USERS

Perhaps the fixed, mobile user scenario is the best candidate for how the U.S. market might initially shape up. In such an application, users can take their phones wherever they want, but they are charged on two levels, Marsh notes.

If they are on the road, users are charged a mobile rate in a similar fashion to current cellular rate structures. If they are at home, users pay rates competitive to current copper local loop service.

However, in one scenario, "home" may not actually be the user's residence. That particular pricing structure could be extended to include a user's neighborhood or town. Conceivably, users might be able to walk to the cor-

cal

Loops

ner market while talking on the phone and still be charged their regular "home" rate.

MARKET APPLICATIONS

This application varies greatly from the proven "substitution" scenario that has served in developing nations, moving to a more "supplemental" approach, where both wireless and copper loops co-exist to serve a market. According to most industry watchers, except in rare instances, most U.S. applications of the wireless local loop will probably supplement rather than substitute copper loops.

According to the Yankee Group's Carlson, most telephone companies have so much invested in copper and fiber, they are much more likely to look at wireline technologies such as ADSL, which lengthens the life of

**Except in rare instances,
most U.S. applications of the
wireless local loop will
probably supplement rather
than substitute copper loops.**

copper and offers superior data rates, than embrace the wireless local loop.

Adds John Aronsohn, a Yankee Group senior analyst, "If Local Multipoint Distribution Service (LMDS) becomes a reality, then there is a possibility of wireless local loop."

There are alternate uses where wireless local loop may come into play, he says. Ameritech has announced it will provide 38 GHz wireless service to connect businesses where traditional wireline connections may be difficult or unfeasible.

Because LMDS is designed for two-way communications, it lets telcos offer Internet access or a group of LMDS services with one-way

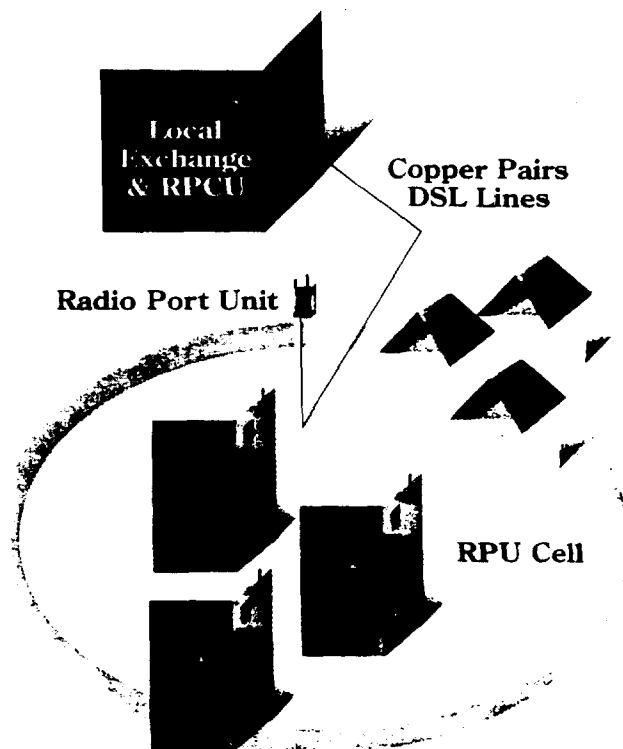


Multichannel Multipoint Distribution Service (MMDS) or Direct Broadcast Satellite (DBS) with WLL as the return path. "Using telephony as the return path is bad," Aronsohn explains, "because it occupies a phone line and negotiating the connection can be slow." LMDS, in contrast, is an ongoing system that waits for the next set of user commands, he adds.

SPECIFIC APPLICATIONS

Essentially, if wireless local loops catch on they could go "anywhere copper can go, where the economics would be favorable," Tadiran's Vida says, adding that there are some specific local loop application needs that seem tailored for wireless technology:

- Flexibility: Simple applications that would be difficult and costly to



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deploy, such as a third residential line (rather than a second), which requires additional rewiring, could easily be solved by a WLL.

- Rehabilitation: Environments where copper wiring has degraded might be more cheaply serviced by wireless technology, instead of refurbishment.
- Economics: Although developing nations usually make the best case for wireless being cheaper than copper local loops, there are instances in the States where the same is true.
- Speed: When carriers require a speedy deployment, a wireless local loop might make more sense than laying copper lines. This could also include stop-gap applications where the final goal is copper, but a wireless local loop would tide users over until deployment is done.
- Transient population. Instances where users will come and go



rapidly, such as wharf or dock areas, which would be costly copper applications, could be well served by a wireless local loop. "But that I see as a more exotic application," Vida says.

According to Peter Nighswander, senior consultant at Washington D.C.-based consulting group MTI, EMCI, campus scenarios are also fertile ground for the wireless local loop. Business parks and industrial areas might be well served, since staff might often be mobile and hard to locate. Rather than force callers into "voice mail jail," a wireless local loop could always keep staff in touch.

Extending the concept to central office service, wireless centrex could provide an almost tailored solution for such applications.

But there remain questions, such as the Yankee Group's Aronsohn

Whether or not data will become a valued facet of the WLL has yet to be determined

continued on page

continued from page 24

curiosity about WLL's durability. The technology is susceptible to weather and line-of-sight problems, he says, and it depends greatly on the frequency used. If the wireless local loop has a breakthrough, he adds, it's more likely to be in second-tier cities, where there is less potential blockage of wireless transmissions than in the larger cities.

IS DATA ESSENTIAL?

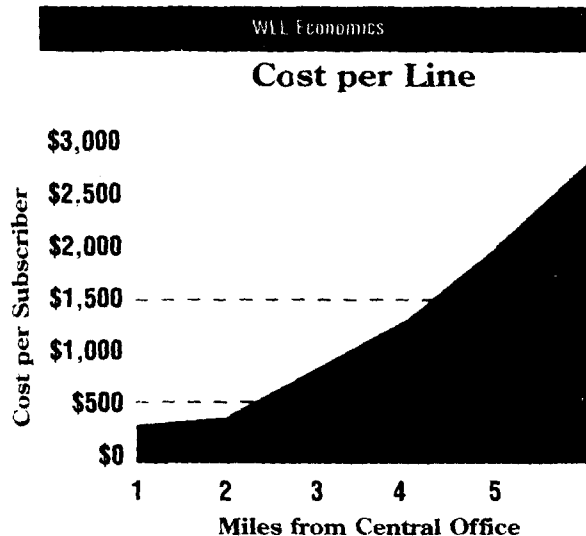
Whether or not data will become a valued facet of the wireless local loop has yet to be determined by the market.

"It's not going to be a market breaker," says Nighswander, who adds that data transmission will most likely be bundled as a value-added service, but won't be a giant factor in the success of U.S.-based wireless loops. "The wireless local loop is going to be predominantly voice." Most industry watchers agree this will be the case—at least at the very start.

According to Motorola's Marsh, wireless data and wireline voice are almost inside-out service offerings. According to Marsh, the bandwidth of wireless isn't adequate to properly serve data demands, especially as customer needs expand to more robust communications that demand equally robust network pipes. Wireline networks would more capably serve those needs.

In a market model in which users employ wireless for flexible, semi-mobile use, Marsh says data will be sufficiently served by second or third copper data lines.

Tadiran's Vida disagrees. He says data will be important, especially in applications in which the wireless local loop is replacing copper networking, rather than supplementing it. In those cases, data will be a necessary facet of the wireless loop,



Source: Tadiran Telecommunications

since there may not necessarily be anything in place to provide that service.

COMPETING TECHNOLOGIES

As the wireless local loop evolves, the technologies that will create it are growing as varied as its market applications. Tadiran's TDMA (Time Division Multiple Access) based MultiGain Wireless system is composed of various small Radio Port Unit (RPU) antennas that are connected to the central office via copper digital subscriber line networks. The licensing costs are relatively inexpensive (less than \$200) because the system operates in the interference-heavy Industrial Scientific Medical band, Vida says. To avoid the IMS band's continuous noise problems, the sys-

tem uses Spread Spectrum Frequency Hopping (see "Artful Interference Dodging," Sept. 15, 1996, America's Network).

Motorola's fixed, CDMA-based WLL (wireless local loop) system, which has been slated for deployment in various developing nations. Given the attention CDMA has received in the U.S., the WLL system should have good cross-over potential for existing cellular and PCS CDMA wireless carriers.

Other WLL technological options carriers will have to

sift through are GSM and the U.S. version of the European Digital Enhanced Cordless Telecommunication (DECT) system, called DCTUS.

WHO IS PLAYING AND WHEN IS THE GAME?

While vision of the wireless local loop is starting to clear, questions remain. Exactly which carriers are in a good position to provide wireless local loop service? What will the exact technology be? When will the market begin to materialize? The answers are tricky to arrive at.

"I think it's definitely PCS, but existing cellular incumbents will have a fairly easy time, because they can upgrade their networks," says MTA-EMCI's Nighswander, adding that cellular and PCS will share 70% to 75% of the U.S. market for wireless local loop. "An overwhelming share will go to PCS," he notes.

That should happen relatively soon, he adds. Already in the trial phase, Nighswander says wireless carriers might implement the technology more heavily over the next three years.

"Next year is going to be magical for these technologies," he says. Within seven years, he adds, "things will really take off."

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As telecommunications monopolies crumble around the world, policymakers are keen to encourage competition not just in long-distance services but also in the more difficult area of local networks. New radio technology could help by allowing smaller companies to bypass the copper wires of incumbent operators and offer a richer range of services.

Recent developments in technology could rewrite the competition rules by allowing new operators to install fixed wireless links that can reach users more cheaply and quickly than conventional wireline connections.

The local loop - the copper wires that link homes and offices to their exchange - has traditionally been one of the most expensive, least profitable portions of the telecommunications network. In rural areas, lines can cost 15 to 30 times as much to install as in cities.

The US, which has had competing long-distance providers for more than a decade, this year decided to open the local loop to competition by ending the local monopolies of the seven "Baby Bells". The European Commission is also keen to encourage alternative local loop providers.

Traditional copper wires cannot easily carry the advanced services that telephone companies want to offer, although researchers have discovered ways to increase the data-carrying capacity. Optical fibre is ideal for broadband services but is too expensive to stretch to every home and office.

Coaxial cable is a more realistic local loop option. It has greater capacity than copper and extensive coaxial networks exist in countries with cable television.

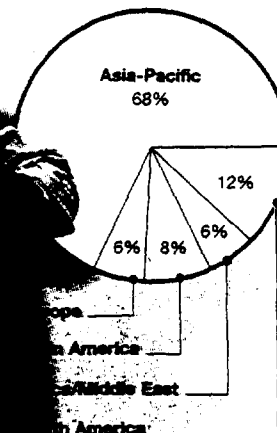
It is technically simple to upgrade these cables to carry telephone calls, although TCI Communications, a leading US cable TV company, estimates that it would cost more than \$200 (£122) a home to do so.

Investors have recently turned against the cable TV companies and their ambitious plans to compete with the Baby Bells in local telephone services. The economies of scale of "wireline" - copper or cable - local loops strongly favour the incumbent operator. Newcomers must build their networks from scratch and digging streets is costly and time-consuming. Payback times are long and only 25 per cent of the homes passed will typically switch to the new operator.

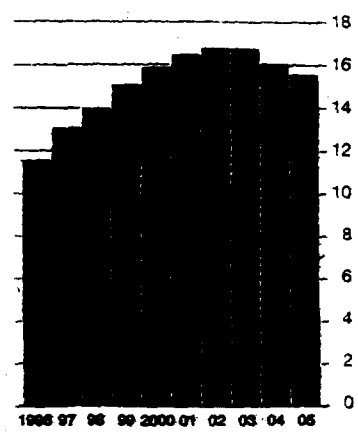
Radio has been used to bring telephone services to rural areas for many years. This continues to be the main market for wireless

A line to the future

Country markets for new lines



Wireless local loop market value (\$m)



Source: Ericsson, Ovum

Another wave

Radio advances are helping small companies compete in local network telecoms, says **Geoff Nairn**

local loop (WLL) technology, particularly in developing countries, but analysts believe WLL is an increasingly attractive option for new operators seeking to enter developed markets.

"The cost of entry is much less than digging up roads," says Adrian May, a consultant with analyst Ovum, which has published a report on WLL. It forecasts the worldwide WLL market will grow from \$11.2bn this year to \$16.5bn in 2001.

Ionica, a new UK operator, is building a nationwide network using WLL to provide its local loop. The company says the cost of connecting each home is just 10 per cent of using wireline connections.

Analysts say the cost differential depends on various factors but accept WLL is generally cheaper and quicker to install than copper infrastructure.

WLL technology was once basic, with poor voice quality, but today's systems can provide services that are indistinguishable from or better than those of the incumbent wireline operator.

Atlantic Telecom is a small UK company that is building a WLL network for 750,000 potential users in the Strathclyde area of Scotland by the end of next year.

A limited service was launched in October and Graham Duncan, the chairman, believes the company can compete with British Telecommunications, the dominant operator, by being "feature-

rich and innovative". Each customer gets two telephone lines as standard. Other benefits include voice mail, portable numbers, local-rate calls within Scotland and, next year, high-speed ISDN access to appeal particularly to Internet users.

Atlantic Telecom was once a cable TV operator but has decided WLL is a more cost-effective method of entering the telecommunications market. "Unlike cable you do not need to

Wireless local loop technology was once basic but can now provide high quality services

pass people who do not want the service," says Duncan, who says it costs the company just £35 to connect each user.

WLL also appeals to established telephone companies that must expand their networks to meet government targets. South Africa is planning to install 1m new telephone lines in the next three years in once-neglected areas such as Soweto.

More than 50 per cent could be realised with WLL, according to Tony Maher, head of access networks for Siemens, the German telecoms equipment maker.

Siemens is bidding for this contract with a no-frills WLL system

based on digital cordless technology, but it is also developing a more advanced technology, called Broadband Code Division Multiple Access (B-CDMA), with US company InterDigital.

This offers better speech quality and higher data transmission rates, but is 30 per cent more expensive than established technologies, says Maher.

"The beautiful thing about B-CDMA is that it can handle raw data better," says Mark Lemmo, InterDigital's marketing vice-president. B-CDMA uses its radio bandwidth more efficiently, he says, and is better suited to dense urban areas than earlier WLL systems.

B-CDMA allocates bandwidth more efficiently than is the case with earlier wireless systems, so it can handle a range of traffic with different bandwidth requirements, from simple phone calls to high-speed Internet access. "There is rapidly growing interest in accessing the Internet using wireless," says Lemmo. InterDigital hopes to demonstrate its technology early next year.

The US companies Lucent, Millicom and Qualcomm are working on competing systems and WLL has become a hot sector with investors. But analysts are cautious about these newer technologies. "Can these companies deliver working systems? That is the crucial issue for telephone companies that want to place orders," says Ovum's May.